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Forestry Research West

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

Forestry Research West

In This Issue

Cover

Forestry Technician Larry Sandoval is using a pressure bomb to help measure moisture stress that seedlings undergo during drought. The study is part of an effort by Rocky Mountain Station scientists to understand the effects of cold and drought on forest tree seedlings. Details begin on page 10

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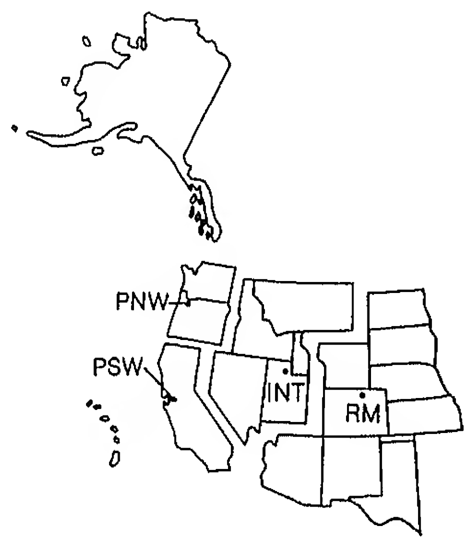


Protecting a research success story

by John McDonald
Pacific Southwest Station

Ground spraying was used in the Sandpoint and Moscow Orchards to protect cones and seeds of rust-resistant western white pine.

Before the introduction of the pathogenic fungi that causes blister rust (*Cronartium ribicola* Fischer), western white pine was one of the most valuable and productive tree species in the northern Rocky Mountains. The subsequent decimation of these magnificent stands and the research that is finally laying the foundation for their successful reestablishment is a story in itself, but that success story is now threatened by a number of destructive seed and cone insects.

Blister rust was first brought to the United States in the 1900's from Europe. It found conditions so favorable in western Montana, northern Idaho, and eastern Washington that it soon virtually eliminated western white pine stands. Within some of these otherwise decimated stands, however, individual trees were found that appeared to be resistant to blister rust.

Through selective breeding of these surviving trees, the Forest Service in the 1950's began an intensive research effort to restore western white pine. This blister-rust resistance program was operated under the leadership of Richard T. Bingham, Intermountain Station's Forestry Sciences Laboratory, in Idaho, until his retirement in 1974. In a landmark General Technical Report entitled *Blister Rust Resistant Western White Pine for the Inland Empire: The Story of the First 25 years of the Research and Development Program*, which he later authored as a volunteer, Bingham wrote:

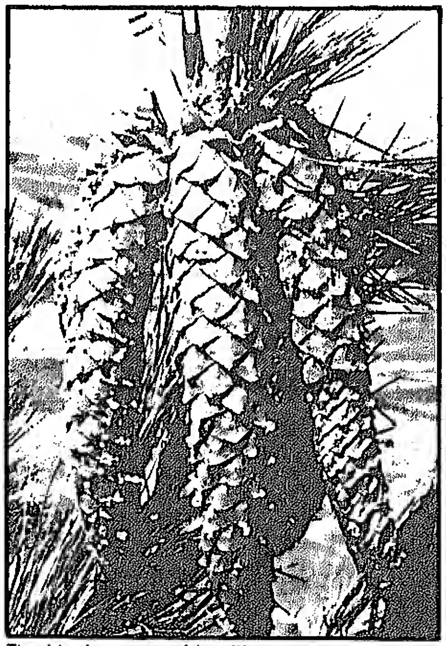
"Twenty-five years of research and development work (1950–75) — first-phase work undertaken by the Forest Service led to experimental production (soon mass-production) of Inland Empire western white pine bred for blister-rust resistance. Breeding has gone through two generations, until 65 percent of the trees resist the intense, artificial exposure to the rust fungus. And unless the racial structure of the rust alters drastically, the long-range survival of these second-generation stocks under natural exposure to the rust probably will exceed 65 percent."

One of the major successes of the breeding program is now demonstrated in three seed orchards, located at Sandpoint, Coeur D'Alene, and Moscow, Idaho. Seed from these orchards are now producing trees that are resistant to the rust fungus.

These orchards, prime evidence of the success of Bingham's research, now need the attention of continung research, because the valuable cones and seed are being attacked by a number of destructive insects.

Probably the most destructive insect has been the mountain pine cone beetle (*Conophthorus ponderosae*), which has caused losses of up to 90 percent of the cones. But at least three other insect species: the western cone seed bug (*Leptoglossus occidentalis*), the lodgepole pine cone borer (*Eucosma recissoriana*), and one or more species of the fir coneworms (*Dioryctria*) have been associated with substantial seed losses.

Focusing on this insect problem, Michael I. Haverty, project leader of a research unit concerned with biology and control of insects adversely affecting regeneration of western forests, and Patrick J. Shea, research entomologist, in cooperation with Michael J. Jenkins, Utah State University, and Forest Pest Management Staff of Region 1, did some early work in 1977 and 1981. Using applications of the insecticide, permethrin, in the Sandpoint Orchard, they evaluated the effectiveness of various concentrations of the insecticide, in addition to timing initial and second applications.



The ideal: a crop of healthy, mature cones of blister-rust resistant western white pine in the Moscow Arboretum.

As a result of this early work, Forest Pest Management officials of Region 1 agreed that similar experiments should be conducted in the other two orchards. The trees range from about 20 to 45 feet tall. Because of the economic importance of western white pine, forest land managers of the northern Rocky Mountains have made the reestablishment of the species to its former habitat a primary objective. The ultimate goal is to develop and implement an Integrated Pest Management system for each of the three orchards.

The three orchards

The northernmost orchard, Sandpoint, Idaho, was established in 1960. It covers about 17 acres and contains 800 grafts from 13 clones of trees determined as resistant to blister rust. Sandpoint has been producing harvestable cones since 1978. Trees in the orchard range from 20 to 45 feet tall.

The Coeur D'Alene orchard is about 42 miles south of Sandpoint and covers about 13 acres. It is stocked by the same tree families that are in the Moscow Arboretum described below. The orchard is just beginning to produce harvestable quantities of cones, but until it matures and produces more pollen on its own, the trees will continue to require artificial pollination.

The third orchard, the Moscow Arboretum, is about 70 miles south of Coeur D'Alene. Beginning in 1957, this orchard was planted with western white pine seedlings that survived intense artificial inoculation with blister rust. The orchard covers about 23 acres and trees range from about 20 to 45 feet tall. Seed produced by this orchard are shared by the 11 cooperators in the Inland Empire Cooperative Tree Improvement Program.

Insecticide spray experiments

For the treatment studies, the insecticides, permethrin, (used in the 1981 work at Sandpoint) and fenvalerate (used in 1984 at Moscow) were chosen on the basis of human safety and efficacy against the mountain pine cone beetle and fir cone worms. The trees were sprayed with a hydraulic sprayer, mounted on a trailer and calibrated to deliver 3 gallons per tree within 48 seconds. Both insecticides were delivered in water solutions.

The Coeur D'Alene orchard was not included in these tests because it is such a young orchard and was just beginning to bear cones.

Mountain pine cone beetle

In the earlier study, done at the Sandpoint Orchard, the target insect was the mountain pine cone beetle. White pine cones require about 15 months to reach maturity. In early spring, as second-year cones begin to elongate, adult cone beetles emerge from overwintering sites within old cones. Female beetles bore into the young cones. The beetles girdle the axis of the cones, severing the conductive tissues, thus killing the cones. The adult females may attack up to four cones, depositing up to 100 eggs. The rapid entry of the beetles into the cones complicates control because once inside the cone, the beetles are virtually invulnerable to externally applied pesticides.

In this study, 10 of the 21-year old grafts were randomly selected to receive one of seven treatments with various concentrations of permethrin. Because timing the treatments to the insect's life cycle is critical for protection of the cone crop, five screened cages, each containing infested cones, were placed within the orchard. Spraying began within one day after the first beetle emerged in one of the cages. Twenty-one days after the last application of insecticide, and after all attacks had occurred, all treated cones were inspected.

The permethrin was applied in concentrations of 0.3, 0.6, and 1.2 percent. The seven treatments consisted of a single application at each concentration, a double application at each concentration, and the untreated controls. The single application at 0.3 percent reduced cone loss from 75.8 percent to 52.0 percent; the single application of 0.6 percent reduced cone loss to 34.8 percent; and the double application at 1.2 percent virtually eliminated cone loss, reducing it from 75.8 percent for the controls to 1.7 percent.

Fir Coneworm

The second study, carried out in 1984 at the Moscow Arboretum, was aimed at controlling the fir coneworm (*Dioryctria*). Although there are other damaging cone and seed insects affecting the Moscow site, the coneworm is by far the most damaging. The fir coneworm attacks the cones of many conifers. It also mines in the buds, shoots, and trunks. Its life cycle is variable and not well known. In the Moscow Arboretum, larvae pupate in cocoons on the ground in August and September and emerge as moths in June. Eggs are laid soon after emergence, and larvae feed from June to September. The larvae mine inside the cone, destroying seed.

The insecticide in this study was fenvalerate, diluted in water to a concentration of 0.25 percent (weight by weight). As before the mixture was applied with a hydraulic sprayer. Control trees received no spray; test trees received one, two, and three applications during the summer. Only trees with an initial cone crop of more than 20 second-year cones were used as test trees.

Treatments were made approximately 30 days apart in May, June, and July. The first application was timed to coincide with the first catch of the target insect in phermone traps placed within the orchard. Before the first application, all cones on the test and control trees were inspected for damage or the presence of adult insects or nymphs.

In July, after the first application, less than 4.0 percent of the treated cones were damaged, while 25 percent of the untreated controls were infested. By August, 46.6 percent of the cones on untreated trees were damaged, while only 13.6 percent sprayed once and 4.1 percent of the cones sprayed twice were damaged. The double application increased seed yield from 31.3 to 56.0 seeds per cone, compared to untreated controls. The third application was apparently not necessary.

Impact of insects on cone seed production

These insecticide studies showed that the earliest damage occurs in the Sandpoint Orchard with the emergence of the adult female cone beetles during late April to mid-May, but the attack period is over by mid-June. At Coeur D'Alene and Moscow, however, scientists have determined, through the use of phermone traps, that visible damage begins in mid-June and continues through August.

"If we are to develop effective pest management systems for these orchards," Shea points out, "it is critical that we accurately assess which insects are there, what their impact is on the rust-resistant seed, and during which period of the year their damage is done. Without this information, we are unable to determine whether insecticide treatment is necessary, and if it is, to specify timing, dosage rates, and number of applications needed to effectively protect this invaluable seed crop."

Immature (nymph) of the western conifer seed bug.

To meet this need, the scientists sampled all three orchards for insect damage during the spring and summer of 1984. Using a hydraulic manlift, they examined all cones on sample trees, and damaged cones were identified, flagged, and coded. At the end of the summer, all damaged cones were removed and dissected. Healthy cones were harvested, counted, and seeds were extracted and sent to Berkeley for analysis. Entomologist Tom Koerber provided radiographs showing mature versus unfilled seed in each batch. (For detailed information on the results of this survey, request *Impact of Insects on Cone/Seed Production in Three Blister Rust-Resistant Western Pine Seed Orchards*, by Patrick J. Shea.)

From the results of this survey, Shea observes: "First of all there appears to be distinct differences in the insect complexes associated with each of the three orchards. There also may be an association between the amount of damage and the number of species present. For instance, the more pest species in the orchard, the greater the damage. Finally, in those orchards with multiple pest species, the insect attack period is generally longer, and the cones and seed are vulnerable for a longer period."

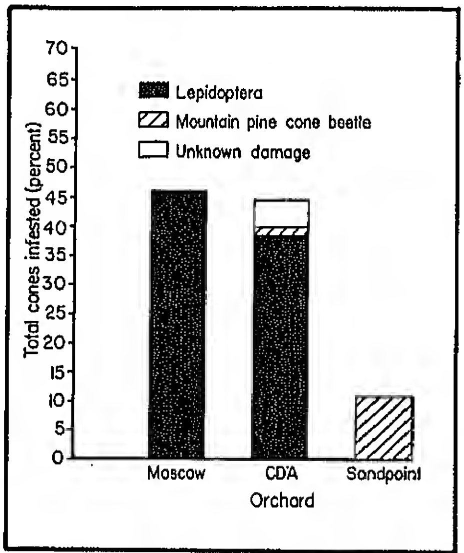
If these observations are confirmed during the remaining 2 years of study, an Integrated Pest Management system could be developed and implemented for each orchard. Management strategies for orchards with multiple pest species might be quite different from those for orchards with a single predominant pest. One might require multiple applications, while a single application might suffice for the other. In addition, one orchard might require only a single monitoring system, while others might require multiple systems.

It appears that data collected in these and future studies could well provide the technological base for IPM systems tailored to each orchard. With seed that is practically priceless, the continued efforts are merited. And the results could well mean the restoration of western white pine to its former habitats and to its former prominence in the timber economy of the northern Rocky Mountains.

For additional information on this subject, request the following papers, available from the Pacific Southwest Station:

Protection of Blister Rust-Resistant Western White Pine Cones from Insect Damage with Permethrin and Fenvalerate, by Michael I. Haverty and Patrick J. Shea. (Presented at the Symposium on Conifer Tree Seed in the Inland Mountain West, Missoula, Mont. August 5–7, 1985)

Impact of Insects on Cone/Seed Production in Three Blister Rust-Resistant Western White Pine Seed Orchards, by Patrick J. Shea. (Presented at the Symposium on Conifer Tree Seed in the Inland Mountain West, Missoula, Mont., August 5–7, 1985.



Percentage of infested cones by insect group in three western white pine seed orchards.

Forest survey research — projecting what's ahead

by Mike Prouty
Intermountain Station

An important function of forest survey research is to develop innovative measurement techniques for woodland species.

"Obviously, a man's judgment cannot be better than the information on which he has based it."

Although Arthur Sulzberger, former publisher of the New York Times is credited with this statement, members of the Forest Survey research work unit at the Intermountain Research Station have dedicated their careers toward translating the axiom into action.

While controversy and emotion run high over proper management and allocation of the Nation's renewable resources, Project Leader Dwane Van Hooser and members of his survey unit work to replace biased generalities with accurate statistics, and emotion-charged statements with assertions based on fact.

As conflicting demands for this country's natural resources have increased, so has the need for accurate information necessary to make resource allocations and land management decisions. Fortunately, legislative direction to provide this kind of information has been in place for over 50 years. Earnest legislative statements of intent are fine, but who is to carry out such an ambitious undertaking? Seven forest survey research work units based in Research Stations throughout the country share the responsibility of inventorying all of the Nation's forest resources.

Of the individual forest survey research projects, the Intermountain Station's has the largest geographic area of responsibility — over 500 million acres encompassing Nevada, Utah, Arizona, Idaho, Montana, New Mexico, Colorado, Wyoming, and parts of Texas and Oklahoma. Almost 138 million acres in this area are forested. The diversity and complexity of the woodland resources of this enormous area provide major challenges and unique opportunities to those assigned the task of collecting and maintaining accurate information about it.

Changing mission

The mission of forest survey has changed since 1928, when section 9 of the McNary-McSweeney act directed the Secretary of Agriculture to make and keep current a survey of timber and forest products necessary for establishing a "timber budget of the United States." Legislators then would never have dreamed that in 1985 charcoal from the lowly mesquite tree (considered a weed in 1928) would be sold for three dollars per 10-pound bag as the ultimate home barbecue medium!

Thus, as use of our resources broadened, so did the need to know more about vegetation other than commercial timber species. The 1974 Resources Planning Act reflected this need by requiring resource information on all forest land, including woodland as well as timberland. While this change in terminology had little impact on forest survey units at most Forest Service Research Stations across the country, it had a profound impact on the workload of the Intermountain Station's project.

Suddenly, millions of western acres of once lowly regarded stands of "scrub" trees like pinyon-juniper, curleaf cercocarpus (mountain mahogany), or mesquite, could not be ignored. Demand for fuelwood, fenceposts, wildlife habitat, and other more esoteric uses required that professional managers have factual, up-to-date information on the quantity and the dynamics of this resource, and legislators recognized this need in the wording of the new law. And so, Van Hooser's project faced an ambitious challenge — not only inventory the vegetation on the additional acres, but devise reliable ways to do so. For never before had anyone accurately tallied the acreage of scrub trees, let alone figured out how many cords of firewood could be had from a pinyon — almost as wide as it was tall — or how many fenceposts or bags of charcoal could be gleaned from a juniper or a cercocarpus tree.

Historical phobia

But why? Why expend the considerable time, effort, and dollars to know how much of something is out there when there seems to be so much of it? Isn't all this business about inventorying both timber and woodlands much to do about nothing?

Not really. Ever since colonial days, when tall, straight white pine were sought as masts for the English navy, the fear of a timber famine has been on the minds of national leaders. This fear of one day running out was an impetus to the early leaders of the conservation movement, and it is very much on the minds of today's legislators, land managers, and timber industry leaders as they struggle to satisfy often conflicting demands of an ever-growing clientele of users of forest resources.

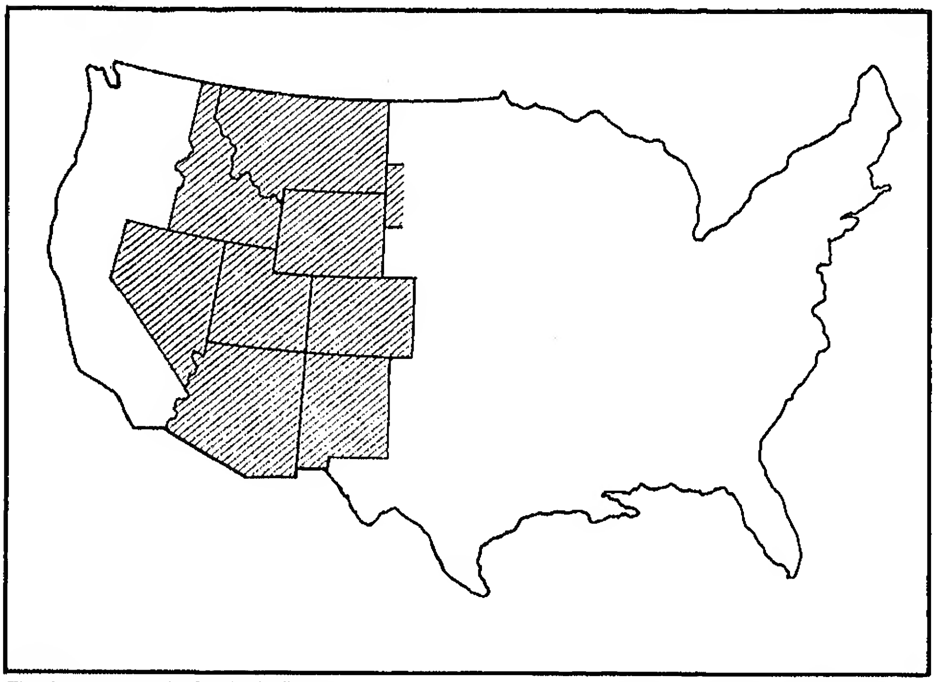
The question "how much" is important to a district ranger in deciding the number of firewood permits or special use permits to issue, or to a wildlife biologist assessing the quality of deer winter range, or to a timber corporation executive deciding where to locate a sawmill.

As a result of this need to know, by the 1960's inventories had been completed for all of the lower 48 states. Approximately every 10 years since then the resources of the nation have been reinventoried. This decadal pattern of forest survey has provided information on trends of use of our resources. Is commercial timber acreage declining? How fast? Is urban development threatening habitat of certain wildlife species? When will this pattern reach the critical stage? Lawmakers use the information provided in these periodic inventories to make decisions that aim to provide for present and future needs. State and federal resource professionals and timber corporation executives are equally concerned about the dynamics of forest resources, for they don't want to shortchange tomorrow's users, or the long-term health of the corporation, because they failed to ignore trends today.

And so the pressure is on Van Hooser's group, and others like his around the country, to provide accurate, reliable information about this country's forest resources. The implications of inaccurate or outdated information are clear, and pose as a heavy responsibility.

Nuts and bolts of forest survey

How does one start to inventory the woodland resources contained within 500 million acres? The job is attacked on a state-by-state basis, with each state in Van Hooser's area of responsibility being reinventoried about every 13 years.



The Intermountain Station's Forest Survey Unit has the largest geographic area of responsibility.

An important first step in preparing to inventory a state involves canvassing the potential users of the survey information — federal, state, and regional agencies, industrial firms, and political and academic organizations — to learn of any particular information needs. If the information desired requires additional expense, the client is asked to contribute necessary funds, people, or equipment.

Of course, the best inventory measures all the vegetation of the area in question. But the impracticality of such a venture dictates that inventories be based on samples that represent the total vegetation. Once the information needs are identified, an inventory design is made and sampling techniques devised. The intensity of the inventory is a tradeoff between obtaining the most reliable information possible (greatest number of samples) within time and dollar constraints.

In most cases, forest resources on state, private, and federal land other than the National Forest System land are inventoried by Intermountain Research Station forest survey crews. Care is taken to avoid duplicating work. Existing surveys by other agencies are used, if compatible with the design of the planned survey. Existing National Forest inventory information in a given state is then combined with the data forest survey crews collect on state and private lands to provide a comprehensive summary of forest resources within a state. Occasionally, forest survey crews will inventory National Forest land if the needed information is lacking and if their assistance is requested.

The prework required to prepare for a survey of a state may take up to a year to complete. Maps and photos covering the entire state must be obtained from a variety of agencies. Sample points are then located on the maps, and land ownership information contained on the maps is recorded for each point. The map points are then transferred to the aerial photographs, where land use information and forest type categories are made through photo interpretation techniques. From these photo points, a subset of points is selected, representing ground plots for the field crews. Finally, packets containing photos, topographic maps, and ownership information are assembled for the field crews. The statistics involved — in arriving at the correct intensity of sample points to achieve an acceptable accuracy of the information collected — is a statistician's dream-world, and another story of its own.

Life on the crew

While statisticians and analysts argue over sample size, standard error, and measurement techniques, the field crews tackle a more mundane but equally important problem — how to convert a pinhole on a large scale aerial photo to a plot location on the ground. Because most states are now being reinventoried, the task is to locate a 2-inch diameter metal stake in the ground (plot center from the previous survey) that was established 10 years ago!

Solving this proverbial "needle in a haystack" problem is viewed a challenge by crew members. The plot centers are inevitably located and the data collected, a result of a combination of keen orienteering skills and a high degree of self-motivation, pride, and professionalism.

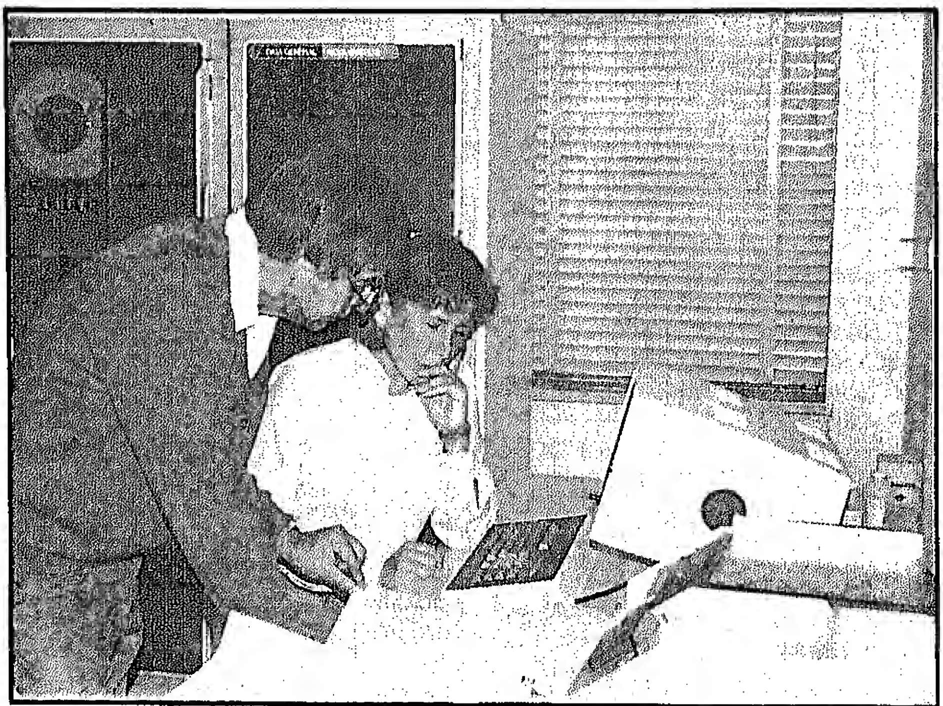
Crew leaders face other problems that make locating old plot centers seem tame by comparison. Permission must be gained from private landowners for the crews to work on their property. Often the landowner only asks that the crews remember to close gates on their way to and from a plot. But just as often a landowner can't be found, and the task of determining the owner and locating him to obtain permission requires hours and days in the county courthouse poring over property maps, and many long-distance phone calls. But the most challenging instances occur when the crews encounter an occasional hostile owner who dislikes or mistrusts "government," and denies access to his land. At such times, interpersonal skills of tact and gentle persuasion are as important to a crew leader as competency with a compass or clinometer. Once the crew boss explains the purpose of the inventory, the owner may consent, but some owners have resolutely denied access, and in these cases the plot is left unmeasured. Fortunately, this rarely occurs, since survey's on-the-ground ambassadors are able to cut through anti-government hostility with sincerity, good sense, and humor.

Life as a crew member is neither easy nor glamorous. They live a transient lifestyle — "home" is a trailer or tent, and never in the same location for more than a month. Privacy exists mainly in the dreams of crew members.

Van Hooser recognizes the value of experienced field crews. The quality of their work affects the rest of the survey process. To prevent "burn-out" he has arranged to rotate his people into positions with the National Forests after 3 years. Knowledge of this opportunity helps keep morale high and places a premium on developing field forestry skills. While experiencing a turnover in personnel, Van Hooser gets highly motivated and competent returnees year after year.

While in the field, the search for plots can take crews to remote areas. They endure long arduous hikes up steep canyons and through dense thorny brushfields, but the pride of finally locating a plot center stake makes the work worthwhile. "It's kind of like a big easter egg hunt," said one crew member, and friendly competition between the two-person crews spurs them to locate and measure as many plots as possible in a day. This same competitive spirit helps maintain a high esprit de corps and serves as an internal pressure for excellence.

After arriving on a plot, the crew sets about collecting a variety of information. These ground plots yield specific information about the area — such as stand condition, productivity, availability, and change in cover type. Information on individual trees is recorded—such as species mix, size, growth, mortality, and stand condition. This informaton is used to formulate silvicultural/management prescriptions, as well as future supply projections and resource trends.



Data analysis requires computer programming and statistical savvy.

Finally, an assortment of information about other resources is gathered — such as recreation and grazing potential or use, wildlife cover characteristics, or watershed and soil qualities. The information is recorded on data cards, checked for recording errors, and submitted for analysis.

From raw data to recommendations

The field crews' diligent efforts result in profuse amounts of data. Once collected, Van Hooser's group faces the task of assembling, organizing, editing, and analyzing this information. This stage in the process requires data processing, computer programming, and statistical and analytical savvy. The emphasis on mathematical sampling methods and technical estimation procedures lends a unique aspect to forest survey research.

In addition to processing the information collected, new methods of estimating and measuring resources represent a significant research function. Unless someone devises a way to measure a mesquite tree having a dozen or more stems, most of them less than 5 inches in diameter, little information about that resource can be collected.

The numbers are "crunched" — sample figures are expanded to represent the entire resource area, tables of figures are built, and projections are made on future supply and resource trends. At this stage, Van Hooser and cohorts attempt to make, as he describes, "intelligent guesses" about the dynamic nature of the resource. "What if" questions are raised and pursued in study of the data, enabling the analysis to make resource predictions and management recommendations.

This information is published in comprehensive statistical reports summarizing forest resources at county, state, regional, and national levels. Special reports are also produced describing individual resources in more detail. This information is used by Congress in setting national programs, by county, state, regional and National Forest planning groups, by forest industry managers in conducting plant feasibility studies, and by private consultants. As Van Hooser describes it, "The information we generate serves as a barometer of the wood fiber situation — including rates of harvest and rates of growth for given areas."

Another important aspect of the survey effort involves forest product studies. As part of the analysis of a state's forest resources, timber product manufacturing and utilization studies are conducted. Surveys of timber industries determine, among other things, how much wood is being processed by a state's wood industries, and how much wood will be required to keep the industry going. Information from these studies is included with the resource inventory data to provide a more complete analysis of the resource supply.

Recommendations and information contained in past reports have provided the impetus for well-known national programs. The National Forestry Incentive Program (FIP) was launched after forest survey data contained in the 1970 national timber appraisal, *The Outlook For Timber in the United States*, showed a great opportunity to increase future supplies of wood existing on non industrial private lands, primarily in the South and East.

As a result, FIP was instigated to provide monetary incentives to private landowners to begin or improve management of their forest lands. As these lands become more productive, they will be able to contribute to the projected future increase in demand for wood products. This is a classic example of how forest survey information can prompt legislative action to ward off future timber shortages.

Continuing technology

Growing demand for the Nation's forest resources will place added pressure for fast, accurate information, and the forest survey organization is working hard to meet the challenge. New inventory techniques, and faster methods of collecting and processing resource data utilizing space age technology are being developed. Already, Van Hooser's group is using satellite imagery in inventorying Arizona's forest resources.

The record established by forest survey over the past 50 years of providing critical information for decision-makers represents a tradition of pride and professionalism. Because of the efforts of forest survey personnel, the future in terms of forest resources in this country is a less unknown, intimidating entity.

Understanding seedling hardiness

by Rick Fletcher
Rocky Mountain Station

Plant Physiologist Pat Heidmann uses a diffusion porometer to measure moisture stress of a ponderosa pine seedling.

In much of the western United States, the most reliable way to regenerate forests is to plant nursery stock. However, seedlings are usually up against a host of environmental factors — two of the most important being temperature extremes (primarily cold) and drought.

A plant's ability to withstand these extremes (its hardiness) is an important attribute that enables it to survive and grow. Despite this importance, little is known about how to determine the hardiness of plants. This and related information are important to nursery operators who often struggle to know the physiological condition of their seedlings, and the optimum time to lift, store and outplant.

To help gain a better understanding of this process, scientists at the Rocky Mountain Station are involved in a new program that is shedding light on how such factors as temperature and moisture affect the growth cycle of seedlings, and their reaction to lifting, storing, and outplanting.

Project Leader Dick Tinus heads the new project "Stress Physiology of Southwestern Tree Species" at the Forestry Sciences Lab in Flagstaff, Arizona. Much of the research is being conducted at the Fort Valley Experimental Forest north of Flagstaff. "Most of our focus is currently on cold and drought hardiness," said Tinus. "In the Western U.S., and particularly in the Southwest, these are the two biggest hurdles for seedlings as they struggle to become established and survive."

Cold hardiness

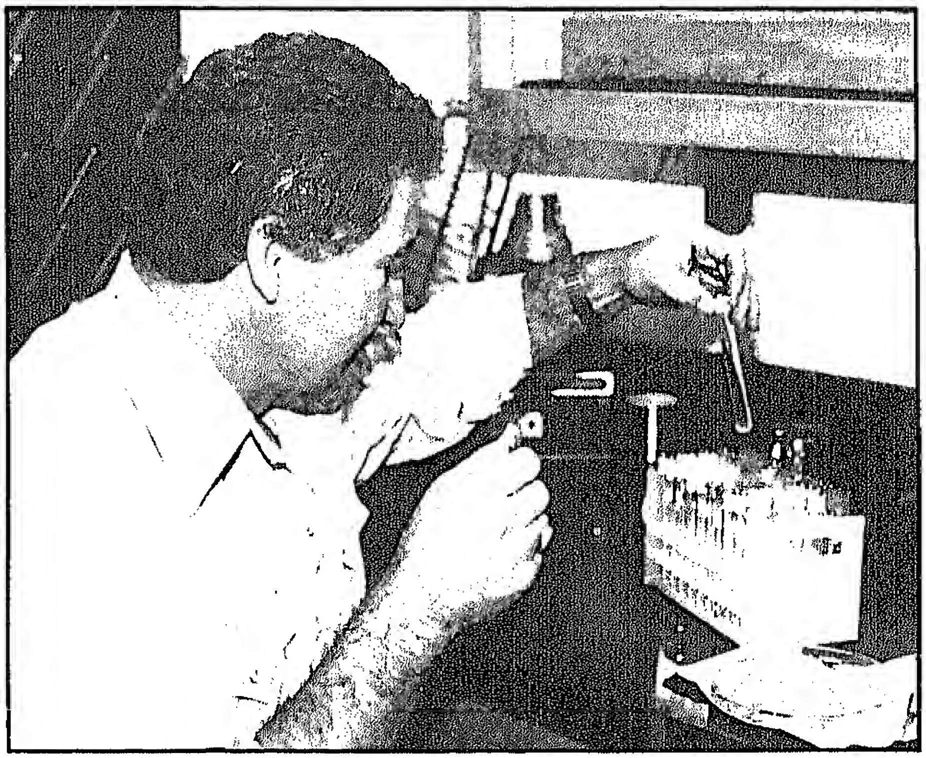
Using growth chambers to simulate fall, winter, and spring, scientists are comparing several different techniques of measuring cold hardiness of ponderosa pine, Douglas-fir, and Engelmann spruce.

One such method is "whole plant freezing". Their roots protected by vermiculite, seedlings are placed in ice chests and loaded into a freezer. As the temperature falls, the chests are removed one-by-one over a temperature range that brackets the expected hardiness from undamaged to dead. The seedlings are then placed in a greenhouse, and monitored for symptoms of injury. From the degree of injury at each temperature, a temperature is calculated which represents 50 percent killing of buds, stems, and needles. Because it needs no calibration, this test is used as a base against which all other tests are compared.

Another, less destructive, test that shows great promise and is helping to verify results from the whole-plant freezing studies uses only a small sample of needles. "What we're doing," said Tinus, "is freezing tissue samples in water. When the tissue cells freeze, they rupture. Fluids then leak from these damaged cells. These fluids contain electrolytes that conduct electricity based on the amount of cell damage, and, when measured, will predict at what temperature the plant will be injured."

One of the benefits of this test is that the whole seedling need not be destroyed. This allows scientists to use the same plant for additional studies. Another advantage is that the results are available in 48 hours, soon enough for a manager to make decisions in time to change the course of events. In contrast, results from the whole plant freeze test are not available for one, often two weeks.

A third endeavor in measuring cold hardiness is called the DTA (differential thermal analysis) tissue test. Graduate student Karen Burr, working with the Flagstaff unit on a cooperative basis, explains, "Different tissues such as buds, needles, and stems all freeze at different temperatures. We're finding that buds are the least hardy. What we're doing is attaching thermocouples to buds and exposing them to low temperatures. At the moment the bud cells freeze, a brief pulse of heat is released. The brief rise in thermocouple temperature appears as a peak on a strip chart recorder, and gives us an indication of the plant's cold hardiness," she said.



Forestry Technician Harvey Hiatt prepares pine needles for a conductivity test.

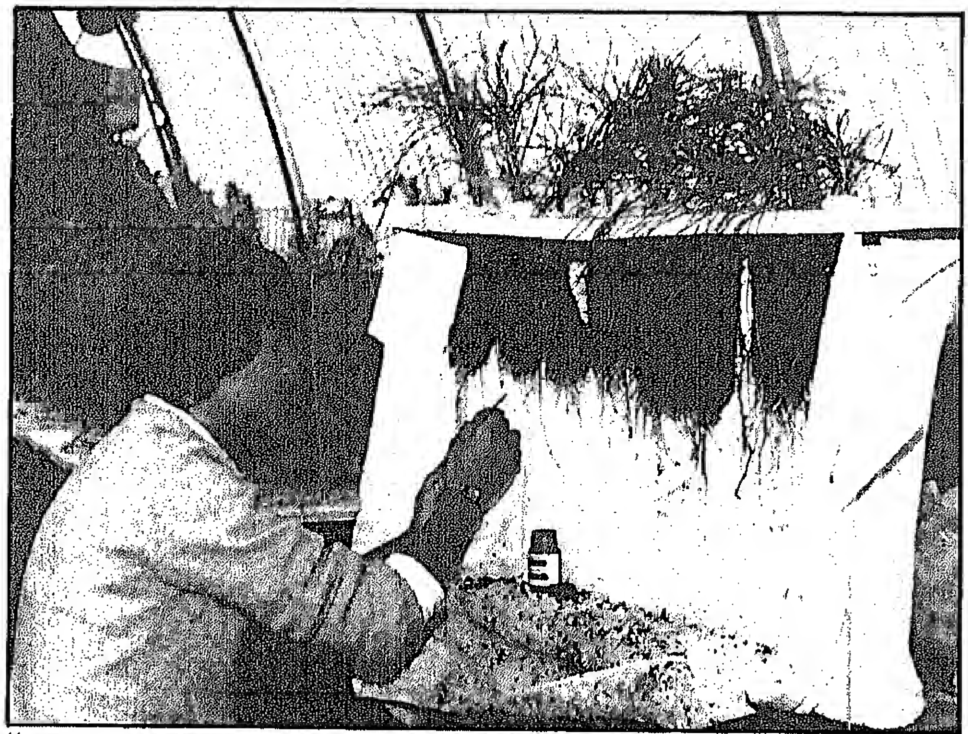
Since the buds are the least hardy tissue, their killing point represents the lowest temperature at which there will be no visible injury to the tree. The test is very fast. It can be completed in 30 minutes. Unfortunately, well-developed buds must be available, which limits its use to the dormant season.

Several interesting results have emerged. Maximum hardiness of Rocky Mountain ponderosa pine was about −32 degrees C., Douglas-fir was −45 degrees, but Engelmann spruce was not killed even at temperatures as low as −75 degrees, the lowest temperature that could be achieved for these tests. Furthermore, the rate of dehardening under warm conditions of all three species was 4 to 5 times the maximum rate of hardening. This has important implications for the storage and handling of nursery stock after lifting.

Tinus says that they're looking for a correlation between tissue and whole-plant freezing, root growth, and days to budbreak. "Although we're just beginning this effort," he said, "we do know that results will help predict when root growth capacity is at its maximum and when to lift seedlings."

Drought studies

Drought is an ever-present problem for reforestation in the Southwest and many other parts of the West. Drought hardiness is a combination of avoidance — the ability to avoid tissue desiccation, and tolerance — the degree of desiccation the plant can stand and still recover when watered.



Here, cooperator Karen Burr paints the exposed roots of seedlings to indicate which have been measured. Root growth potential, which takes 14 days to measure, may be estimated from cold hardiness which can be measured in 30 minutes to 2 days.

Studies indicate that southwestern ponderosa pine is a very drought-tolerant species. Container and bare-root seedlings were planted in sedimentary or basalt (volcanic) derived soils in individual pots lined with a plastic bag. After saturating the soil, the top of each bag was tied shut around the stem at the soil line to eliminate evaporation. Pots were not watered thereafter. Examination of the data indicates that ponderosa pine seedlings are able to withstand moisture stresses beyond what had previously been thought. In a preliminary study, no seedlings which had been subjected to drought for 135 days died. In some cases, soil moisture tensions may exceed that measurable with thermocouple psychrometers (–80 bars). Plant moisture stress (PMS) as measured with a pressure bomb using needle fascicles often exceeded –62 bars. After re-watering, some of these trees survived and within 40 hours PMS readings dropped to –10 to –12 bars. (For comparison, soils at –80 bars would feel bone-dry; –15 bars is the usual wilting point for these trees; 0 to –1 bar would be well-watered).

Stomata of trees subjected to prolonged moisture stress open for short periods in the morning then close, whereas stomata of non-stressed trees remain open until the afternoon. These results indicate that, under severe moisture stress, ponderosa pine seedlings essentially shut down. Future studies using tritiated water will determine if seedlings subjected to severe drought are able to absorb moisture from the atmosphere.

Stomatal behavior

A closely-related endeavor involves a cooperative effort with the Pacific Southwest Station. Research Forester Phil Weatherspoon has been working at Fort Valley to see if there is any correlation between cold hardiness, dormancy, and stomatal behavior of tree seedlings. He and Forestry Technician Laura Towner are using a thermal infrared scanner to measure the surface temperature of seedlings. "When stomates are open," explained Weatherspoon, "the loss of water cools the foliage. When the stomates close and transpiration ceases, the needles get warmer."

Their hypothesis is that, during the growth cycle of healthy plants, stomates are more active (opening during day, closing at night), and as the plant moves into the dormant stage or experiences stress of some kind, the stomates become less active.

"By better understanding stomatal behavior and how it relates to the physiological condition of seedlings, we may be able to estimate one aspect of plant condition, such as dormancy, which is difficult or time-consuming to measure, by direct measurement of another such as stomatal behavior, which is quick and simple to measure. By doing so, we hope to provide better tools to guide nursery and reforestation management," said Weatherspoon.

Although their mission is just beginning, project scientists feel they have a good jump on understanding the effects of cold and drought on seedlings. As these studies are refined, further tested, and verified, nurserymen, reforestation specialists, and tree planters will find they have better tools for seedling production and outplanting quality control. "Our main goal, and the bottom line," said Tinus, "is to provide the knowledge needed to attain a higher degree of reliability and predictability of successful reforestation. "

Further details on this research can be found in the following reprints, available from the Rocky Mountain Station:

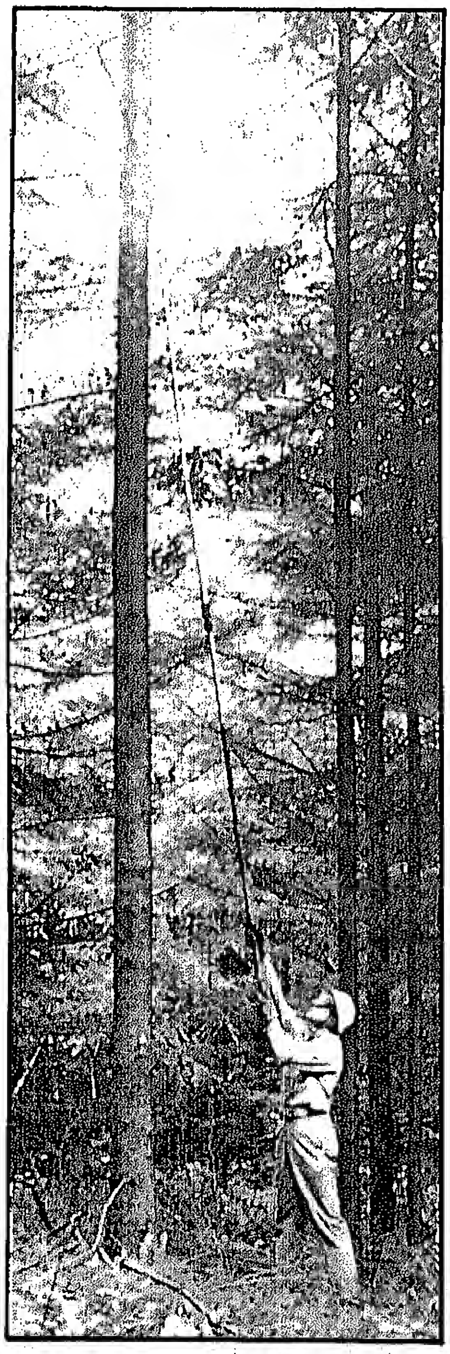
Estimation of Cold Hardiness of Douglas-fir and Engelmann Spruce Seedlings by Differential Thermal Analysis of Buds, which appeared in Annals of Applied Biology (1985), 106, 393–397.

Cold Hardiness Testing of Conifer Seedlings, in Proceedings; Intermountain Nursery Association Meeting, August 13-15, 1985, Fort Collins, Colorado.

Phil Weatherspoon and Laura Towner adjust their instruments as they measure the surface temperatures of seedlings with a thermal infrared scanner.

How about pruning Douglas-fir?

by Dorothy Bergstrom
Pacific Northwest Station



Pruning Douglas-Fir—an old idea that hasn't quite materialized—may be getting a closer look as a result of a recent product recovery study conducted at the Pacific Northwest Station. This study suggests that pruning may be profitable in managed forests and provides new impetus for plans to include pruning in studies of silvicultural methods.

Pruning (removing the lower limbs from trees) speeds up a natural process that occurs as trees grow taller and less light reaches the lower crowns. After the lower branches are removed, the new growth is clear rather than "knotty." In general, clear wood is considered stronger and more valuable than wood formed earlier. During the past 10 years, for example, high-grade veneer made from clear wood has been worth about twice as much as construction grade veneer, and the price for select Douglas-fir lumber has been two or three times that of structural grades.

The revived interest in pruning is the result of increased costs for labor and money. Increased labor costs have reduced the amount of commercial thinning, which was once seen as a practical way to increase growth (and profits) on residual trees. And the high interest rates of the 1970's increased the cost of investing in forestry plantations—with the result that commercial timberland owners want to grow trees faster to get a faster return on their investment.

As a result of these economic facts of life, seedlings are now planted at wider spacing and trees have bigger limbs that stay on the boles longer. Wood from intensively managed stands is substantially lower in quality from wood produced in natural stands, and pruning is beginning to gain favor as a way to improve wood quality.

Pruned logs produce more clear products

In a product recovery study conducted at the Pacific Northwest Station in 1984, pruned Douglas-fir produced more clear products of higher value than unpruned Douglas-fir. The increased value was probably enough to offset the cost of pruning and still return a profit. The study is significant because it is the most comprehensive of several studies on product recovery from pruned Douglas-fir: (1) trees had the longest growth period following pruning; (2) trees were processed into both lumber and veneer to meet current standards; (3) processing was done in modern facilities; and (4) complete growth records on all trees made it possible to document results.

The product recovery study was an unexpected bonus of a study started in the late 1940's by Pacific Northwest Station researchers in the Voight Creek Experimental Forest southeast of Tacoma, Washington. The purpose of that study was to look at pruning costs. The product recovery study was made possible in 1984, when the timberland owner (St. Regis Corporation) decided to cut the stand.

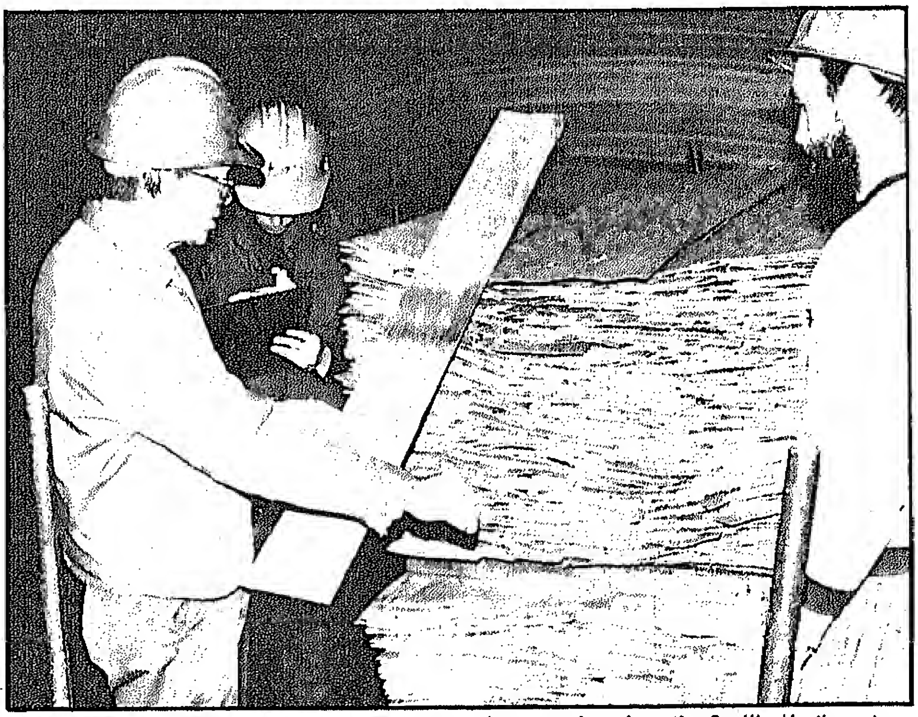
Jim Cahill, a research forester with the Timber Quality Research Unit in Portland and leader of the product recovery study, says the opportunity to conduct the study was too good to pass up because, "Turning trees into products is the only way to measure the results of pruning. The payoff is in the increased value of the products."

Trees pruned in 1950 were cut in 1984

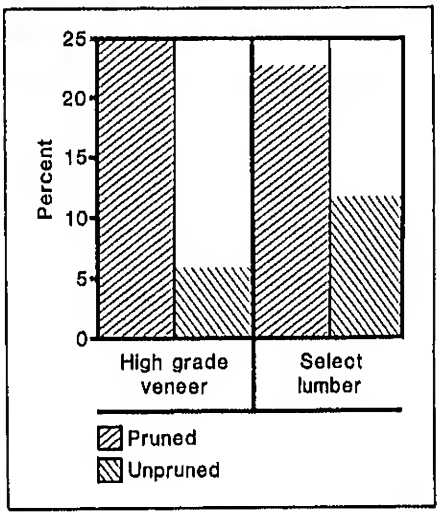
Most trees in the study area were 38 years old in 1950, when they were pruned to a height of 17 feet. At that time, the trees were about 12 inches n diameter (dbh). When the trees were cut in 1984, they were about 72 years old and averaged about 20 inches in diameter.

Cahill and an assistant selected the study trees to supply logs in a range of sizes, remeasured them, and worked with the logger during cutting. Study logs were the butt logs from 200 pruned trees and 100 unpruned trees. Because complete records were available, logs for the study were selected to represent a range of sizes at the time of pruning and amount of growth after pruning. Half the logs were peeled for veneer and half were cut into cants, then into lumber.

Although the trees—at age 38—were well past the age at which pruning would be done in a commercial operation, the pruned trees produced more products of higher value than did the unpruned trees.



Crew members from the Pacific Northwest Station tally random width veneer at the North Pacific Plywood mill in Graham, Washington.



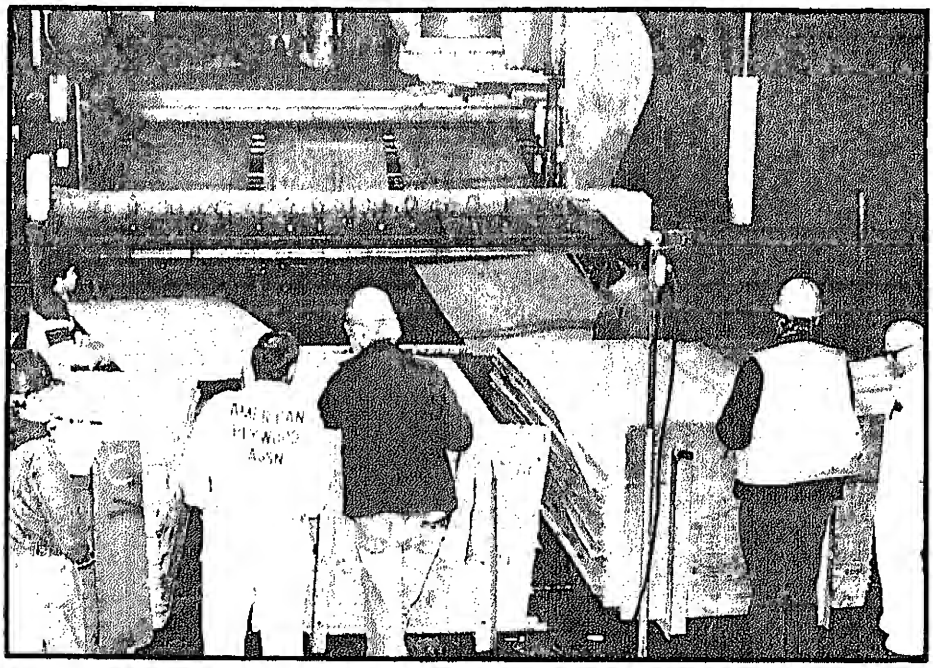
The amount of clear product increased with the radius of clear shell. Cahill considers the results conservative, because the study trees were pruned so late.

Costs of pruning

Costs were not part of Cahill's study, but the costs of pruning the Voight Creek trees were reported in a 1950 publication from the Pacific Northwest Station (*Financial Aspects of Pruning*, by Elmer W. Shaw and George R. Staebler). Costs were based on pruning time per tree, which ranged from 2 minutes for trees 5 inches in diameter to 4.20 minutes for trees 14 inches in diameter. The time required for pruning varies with a number of factors that include skill of workers, trees per acre, size of trees, number and size of limbs, steepness of terrain, and tools available for the job.

Cahill says that three factors are needed to evaluate the feasibility of pruning: (1) the cost of pruning, (2) the difference between the value of clear wood and knotty wood, and (3) interest rates, or the cost of investing money in pruning over the years between pruning and harvest.

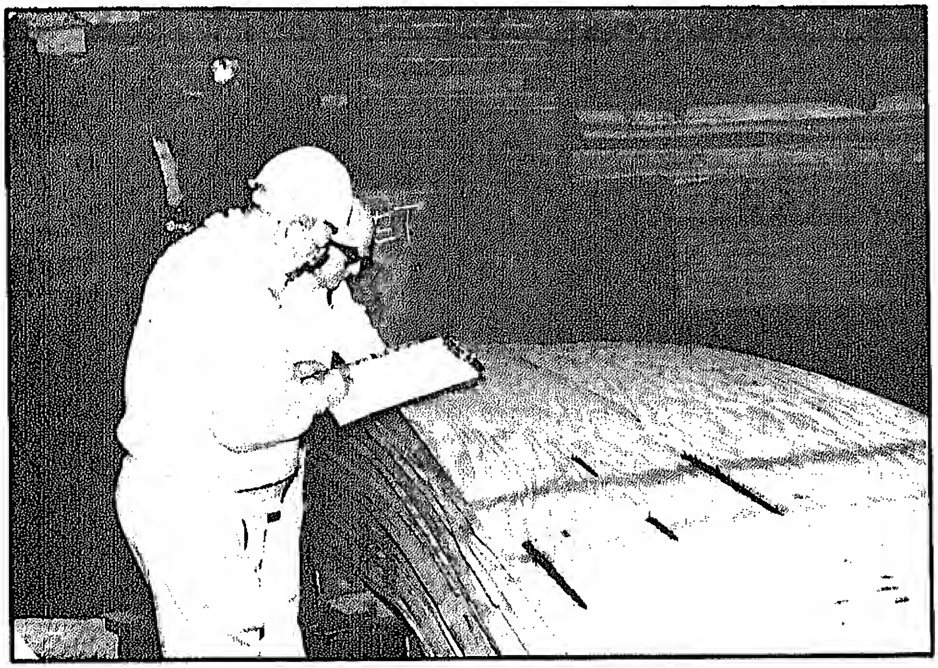
Three previous studies of product recovery from pruned Douglas-fir showed positive results—more of better grades of products produced from pruned logs. Those studies were done with smaller numbers of logs (5 to 18) between 1957 and 1962, when product standards and processing technology were somewhat different from those of 1984. A fourth, considerably larger, study done in 1978 produced negative results. That study, however, was made only 20 years after pruning—too short a time for enough clear wood to grow and substantially improve product quality.



Crews from the Pacific Northwest Station and American Plywood Association grade full sheets of plywood as they emerge from the dryer at the North Pacific Plywood mill in Graham, Washington.

Unpruned Douglas-fir produced little clear wood

Pruning is the only way to produce a significant volume of clear wood from intensively managed young-growth Douglas-fir. Douglas-fir is so slow at natural self-pruning that widely spaced trees produce little clear wood by the usual rotation ages. Studies (1939–51) indicate that unpruned Douglas-fir takes between 77 and 100 years to produce a clear 17-foot log with some volume of clear wood.



The Pacific Northwest Station crew that graded plywood at the North Pacific Plywood mill in Graham, Washington, included Don Martin, a Forest Service volunteer.

Pruning should be done when trees are quite young (15–20 years old) to keep the knotty core small and allow quick healing of scars. The recommended practice is to prune the lower 17 feet to allow for a 16-foot butt log of clear wood. Studies indicate a third of live crowns can be removed without damaging trees or reducing growth rate. Removing too much live crown can reduce both diameter and height growth.

When the Voight Creek trees were pruned, the expectation was that pruning would be needed to provide the volume of high-grade logs needed to sustain plywood production at the levels of the late 1940's. Pruning fell out of favor, however, because labor costs increased in the late 1950's and attempts to automate pruning were unsuccessful. Also there was still a supply of high quality logs from old-growth timber available.

Many questions remain about the advantages, results, and methods that should be used in pruning. For example, will there be enough clear wood to keep processing plants in business? If there is little clear wood, will the demand for it drop off? What is the best way to select candidate trees for pruning? How should pruning equipment and technology be brought up to date?

The next step

The next step in Cahill's study will be to inccorporate the product recovery data into the DFSIM (Douglas-fir Stand Simulator) Program. This will make it possible for managers to calculate the economic feasibility of pruning along with other factors.

Cahill is preparing a report about the study. In the meantime he will be glad to answer questions. Call him at 503/231-2103 (FTS 429-2103).

New publications

Eliminating and creating snowdrifts

Artificial barriers such as snow fences are commonly used to help protect livestock from winter winds. However, during major storms, these barriers can cause snowdrifts that bury or trap livestock.

Results from studies done by Rocky Mountain Station scientists indicate that properly designed barriers will not only safely protect livestock, but can be designed to create snowdrifts to enhance the water supply for stock ponds.

Using scale model fences and other shelter-type structures, along with full-scale field tests, scientists found that tall shelters (3.7 – 5 m) should be used where snowdrifting is a problem. The best site for a livestock shelter is one where the open (downwind) side faces a natural snow accumulation area such as a stream channel or depression.

To help provide water for stock ponds, earth embankments around the pond should be confined to the downwind half of the pond, and a 50 percent porous snow fence be placed near the upwind edge of the pond. A snow fence placed on top of a windward embankment will also increase snow deposition within the pond.

Details on this research, along with further recommendations, are available in the reprint *Model Studies of Snowdrifts Formed by Livestock Shelters and Pond Embankments*, from 53rd Western Snow Conference Proceedings, pages 167–170, Boulder, Colorado, April 16–18, 1985, 183 p. Western Snow Conference, Spokane, Washington.

Slope stability proceedings published

Slope stability problems in the mountainous forests of the Western United States, Canada, and Alaska were the subject of a comprehensive review at a workshop in 1984 at the University of Washington. The workshop provided information on the activities and findings of a USDA Forest Service research program begun in 1972 by the agency's Pacific Northwest, Pacific Southwest, and Intermountain Experiment Stations. The western regions of the Forest Service, universities, and other Federal agencies have also been involved with the three Stations in learning about and sharing information on soil mass movement.

The proceedings of the workshop are now available. Included are 15 papers and 15 other presentations given as part of panel discussions. *Proceedings of a Workshop on Slope Stability: Problems and Solutions in Forest Management*, General Technical Report PNW–180, is available from the Pacific Northwest Station.

Symposium — fire's effects on wildlife habitat

An important goal of a 5-year Intermountain Research Station research and development effort on "Fire Effects And Use" was to better understand the effects of fire on plant communities.

There is growing recognition by land managers of the positive effects of fire, and they are using prescribed fire to rejuvenate wildlife habitat. These managers need to know how weather, fuel arrangements, and ignition patterns influence the effectiveness of these burns.

Believing the future of wildlife depends on maintenance of its habitat, and that fire is an important tool in this effort, a symposium was held on March 21, 1984 in Missoula, Montana, to assemble and share information on this subject. Request, *Fire's Effects on Wildlife Habitat — Symposium Proceedings*, General Technical Report INT–186.

Riparian conference proceedings published

Riparian ecosystems are becoming more a focus of attention for land managers as the demand for their resources increases. Not only do they offer livestock grazing, timber products, and agricultural and recreation opportunities, but they usually support more diverse plant and animal communities than surrounding ecosystems.

The Rocky Mountain Station, in conjunction with the Soil Conservation Service, Bureau of Land Management, Bureau of Reclamation, Fish and Wildlife Service, and the University of Arizona, recently sponsored the First North American Riparian Conference in Tucson, Arizona, April 16–18, 1985. Over 100 papers were presented, covering: the ecology, hydrology and physical characteristics of riparian ecosystems; multiple-use planning and management; legal and institutional needs; riparian ecosystems in dryland zones of the world; and riparian resources, i.e. recreation, agriculture, wildlife, livestock use, fisheries, and amphibians and reptiles. Twelve symposium poster presentations are also reviewed.

When free copies of the 523-page General Technical Report RM-120 *Riparian Ecosystems and Their Management: Reconciling Conflicting Uses* run out, it will be available for $40.95 ($5.95 on microfiche) from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. Request number PB 86103967–AS.

Everything about aspen

The Rocky Mountain Station has issued a major publication on the ecology and management of aspen in the western U.S. A compilation of information from a variety of sources, it is a good reference book for anyone interested in *Populus tremuloides* Michx. It is also the first comprehensive book of its kind that focuses exclusively on aspen in the western United States.

The publication is organized in four parts: *The Tree* – reviews the biology of aspen as a species; *Ecology* – reviews environments and community relationships; *Resources and Uses* – considers the resources available in and from the aspen forest type; and *Management* – covers silvicultural methods and management approaches.

Single copies of *Aspen: Ecology and Management in the Western United States* are available from the Rocky Mountain Station, as General Technical Report RM–119, while supplies last. Additional copies may be purchased, under stock number 001–001–00617–3, from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $8.50 each.

Costs of managing nontimber resources

How do timber sale requirements and objectives regarding soil and water, wildlife, and scenic quality affect the stumpage value of a sale? And how do these requirements affect the margin timber purchasers bid over and above the estimated stumpage value?

While the management of all resources of National Forests is closely tied to timber harvesting, there has been little information on the cost of managing nontimber resources when harvesting timber.

Research Forester Robert Benson and Economist Michael Niccolucci, Intermountain Research Station, studied 187 timber sales on seven National Forests in the Northern Region between 1975 and 1981. Their analyses estimated that, in terms of 1980 dollars, it cost an average of $26 per thousand board feet in terms of reduced stumpage receipts for meeting nontimber resource management concerns. Forest Service administrative costs were not included in the study.

To obtain a copy of this report request, *Costs of Managing Nontimber Resources When Harvesting Timber in the Northern Rockies*, Research Paper INT-351.

Cubic measurement explained for forestry use

A new handbook is available to assist people with the use of cubic volume measurements in forestry. Titled *User's Guide for Cubic Measurement*, it is the result of a workshop on cubic volume held in Portland, Oregon, in April 1983, and was published jointly by the University of Washington and the Pacific Northwest Station.

Chapters cover the range of forestry uses, from inventory of standing timber to marketing, and include silviculture, cruising, appraisals, bidding, harvest and transport, residues, and scaling. Each chapter gives an overview of the purpose of measurement in that activity, discusses the advantages and disadvantages of cubic measure, and shows how to apply it. The 20 authors are forestry experts with practical experience in both the theory and practice of cubic measurement.

Cubic volume is suitable for measuring wood in any form and appropriate for all stages of forest operation from growing trees to marketing products.

The new book may help cubic volume replace the board foot—an outdated, inconsistent, and inaccurate theoretical unit of measure that gives estimates of the amount of lumber that can be recovered from big trees but tells nothing about other wood products from smaller timber. The cubic foot can replace the many board-foot rules, cords, and other traditional measurements. It is increasingly used by silviculturists and has been adopted by a number of forest product firms.

According to the book's authors, resistance to giving up the board foot is hard to understand in an industry that depends on accurate measurements. Now may be the time for change, however, partly because cubic measure is increasingly used in international forestry operations, and in difficult economic times cubic measurement could be a way to "sharpen up" a company's operation with only a little brain power and not much cash outlay.

User's Guide for Cubic Measurement is available from the University of Washington, College of Forest Resources AR-10, Forestry Publications, Seattle WA 98195. Checks ($10 per copy) should be made to University of Washington.

Study helps in monitoring stream sediment loads

Land planning legislation has required land management agencies to systematically monitor the effects of their activities.

One of these effects being monitored is the amount of sedimentation in streams near logging and other land-altering operations. Such sediment loads can adversely affect water quality and fish habitat.

Because most suspended sediment moves during infrequent high flows, and this is when measurements must be taken, the infrequency and brevity of high flows and measurement and access problems complicate data collection.

A new report describes the administrative and technical problems that define what to measure and how to measure suspended sediment in small mountain streams. It examines the factors that govern the quality of data collected in a monitoring program, with particular attention on use of automatic pumping samplers.

For further information, request *Measuring Suspended Sediment in Small Mountain Streams*, General Technical Report PSW-83.

Management guidelines available for mountain meadows

Until the onset of development of western lands, the historic uses of mountain meadows had little adverse effect. But the gold rush of 1849 produced a need for beef production. The wool industry also increased, and the result of these changes led to widespread overgrazing and deterioration of meadowlands.

Effective control on Forest Reserves began when the Forest Service started requiring grazing permits; but this did not help the situation on non-agency lands. The multiagency concern that the geologic and biologic stability of mountain meadows be maintained or restored led to several studies. Their results have produced bodies of knowledge that are now available to guide the management of these fragile sites.

In his publication, Ray Ratliff, of PSW Station, range management research unit at the Forestry Sciences Laboratory in Fresno, California, discusses the classification, productivity, and management problems associated with meadows in the Sierra. He outlines guidelines for the maximum percent of grazing desirable for various types of meadows. He summarizes the effects of timing, frequency, and degree of defoliation on productivity of meadows; and he covers other such impacts as trampling, patterns of preferential grazing, nutrient redistribution, rodent activities, invasion by lodgepole pine, fire, and gully erosion.

Ratliff observes that how a meadow site measures up is indicated by its condition; but how management measures up is indicated by the trend in condition. Good range management must be practiced and must include proper use, restoration efforts, monitoring condition trends, and user education.

For more information, request *Meadows in the Sierra Nevada of California: State of Knowledge*, General Technical Report PSW-84.

Mixing leguminous and eucalyptus trees increases productivity

Because of their quick growth and high yields, two *Eucalyptus* species are especially favored for wood, fiber, and fuel production in Hawaii; but their growth is limited on sites with low levels of available soil nitrogen.

To study the effects of supplemental nitrogen, a study was carried out by Dean DeBell (PNW's Forestry Sciences Laboratory in Olympia, WA), Craig Whitesell (PSW's American Pacific Islands research unit, Honolulu, Hawaii), and Thomas Schubert (BioEnergy Development Corp., Hilo, Hawaii). Pure eucalyptus plantings were compared with those interplanted with Acacia, and those interplanted with Albizia (both of which are leguminous trees). Leaf samples were collected at 14 months and analyzed for N, P, K, S, Ca, and Mg; and soil samples were analyzed at 65 months for pH, N, P, K, Ca, and Mg.

At 65 months, Eucalyptus grown with Acacia were 25% taller and 28% larger than those in pure stands; and those grown with Albizia were 63% taller and 55% larger. Despite increased mortality of Eucalyptus trees in mixed species treatments, differences in biomass yields per ha were even greater than differences in average tree size.

This study demonstrates the potential for using leguminous trees in mixture with Eucalyptus for increased production in biomass plantations in Hawaii. For further information, request *Mixed Plantations of Eucalyptus and Leguminous Trees Enhance Biomass Production*, Research Paper PSW-175.

Managing rangeland as wildlife habitat

A new publication in the Pacific Northwest Station's series *Wildlife Habitats in Managed Rangelands — the Great Basin of Southeastern Oregon* describes habitat for terrestrial vertebrates. It comes in two parts—a text that describes the relationship of terrestrial vertebrates to plant communities and structural conditions, and a 208-page appendix of detailed ecological information.

Earlier publications in the series were announced in Forestry Research West (February 1980 and January 1983). Twelve have now been published, and three more are planned.

Copies of the new report are available from the Pacific Northwest Station. Ask for *The Relationship of Terrestrial Vertebrates to Plant Communities and Structural Conditions*, General Technical Report PNW-172.

Wilderness study reveals use trends

Unless wilderness managers grasp changing trends in the recreational use of wilderness, their efforts could be misdirected and inefficient. Managers need information on current conditions as well as dynamics of change so their efforts can be proactive rather than reactive.

A new report from the Intermountain Research Station provides information on how visitor characteristics and use of the three areas in the Bob Marshall Wilderness Complex changed in 12 years. Questionnaires were distributed to wilderness visitors in 1982 that were basically identical to those used to study visitors to the same area in 1970.

Robert C. Lucas, Research Social Scientist at the Forestry Sciences Laboratory in Missoula, Montana, used data from almost 1,300 questionnaires to study changes in visitor characteristics, attitudes, and use patterns. His study reveals a shift from horse use to mainly backpacker use, and this basic change is reflected in several other user differences noted in the study.

For example, although visitor characteristics and attitudes were generally stable, complaints about trails were six times as common in 1982 as in 1970. Other than trail improvements, visitors questioned in 1980 were opposed to facilities and more supportive of actions to preserve natural ecosystems. The study suggests trail deterioration is the top priority problem to managers of this area. In the good news category, typical parties had lower potential for impacts on the wilderness resource.

For more information, request, *Visitor Characteristics, Attitudes, and Use Patterns in the Bob Marshall Wilderness Complex, 1970-82*, Research Paper INT-345.

Estimating volume of woodland trees

In the arid Rocky Mountain regions, vast acreages of trees once ignored by foresters are now drawing attention as a source of wood. Thus, simple cost-effective volume measurement methods are needed for species of pinyon, juniper, mesquite, and oak, among others. The shrub-like, multiple-stem character of these trees makes conventional methods of measurement impractical and inaccurate, because a large percentage of the volume is found in the branches and the main trunk is not well defined.

In a new report, Forester David Born and Research Forester David Chojnacky of the Intermountain Research Station describe a visual segmentation technique that can be used in developing volume equations for these woodland species. For more information request *Woodland Tree Volume Estimation: A Visual Segmentation Technique*, Research Paper INT-344.

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

- ☐ *The Relationship of Terrestrial Vertebrates to Plant Communities and Structural Conditions*, General Technical Report PNW-172.
- ☐ *Proceedings of a Workshop on Slope Stability: Problems and Solutions in Forest Management*, General Technical Report PNW-180.
- ☐ *Economic Considerations*, General Technical Report PNW-181.
- ☐ *Influences of Recreation*, General Technical Report PNW-178.
- ☐ Other ______________________.

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- ☐ *Aspen: Ecology and Management in the Western United States*, General Technical Report RM-119.
- ☐ *Riparian Ecosystems and Their Management: Reconciling Conflicting Uses*, General Technical Report RM-120.
- ☐ *Model Studies of Snowdrifts Formed by Livestock Shelters and Pond Embankments*, a reprint.
- ☐ Other ______________________.

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Please send the following Intermountain Station publications:

- ☐ *Woodland Tree Volume Estimation: A Visual Segmentation Technique*, Research Paper INT-344.
- ☐ *Fire's Effects on Wildlife Habitat — Symposium Procceedings*, General Technical Report INT-186.
- ☐ *Visitor Characteristics, Attitudes, and Use Patterns in the Bob Marshall Wilderness Complex, 1970–82*, Research Paper INT-345.
- ☐ *Costs of Managing Nontimber Resources When Harvesting Timber in the Northern Rockies*, Research Paper INT-351.
- ☐ Other ______________________.

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Please send the following Pacific Southwest Station publications:

- ☐ *Protection of Blister Rust-Resistant Western White Pine Cones from Insect Damage with Permethrin and Fenvalerate*, a reprint.
- ☐ *Impact of Insects on Cone/Seed Production in Three Blister Rust-Resistant Western White Pine Seed Orchards*, a reprint.
- ☐ *Meadows in the Sierra Nevada of California: State of Knowledge*, General Technical Report PSW-84.
- ☐ *Measuring Suspended Sediment in Small Mountain Streams*, General Technical Report PSW-83.
- ☐ *Mixed Plantations of Eucalyptus and Leguminous Trees Enhance Biomass Production*, Research Paper PSW-175.
- ☐ Other ______________________.

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Help needed on the Western Spruce Budworm Model

Scientists want forest managers to use the Western Spruce Budworm Model and tell them how it is working. Feedback from managers will help shape and refine the model into a tool for making decisions about forest stands that are susceptible to budworm outbreaks.

The Western Spruce Budworm Model is a mathematical representation of what is known about the insect. It organizes and displays information about such factors as the effects of defoliation, weather, and interactions between insects in neighboring stands. The model is designed to help managers who have budworm problems in their forests predict the impact of infestations on stand yield. When linked to a growth and yield predictor, like the Prognosis Model, it can also be used to explore the long-range effects of various management regimes, as might be done, for example, in developing a Forest plan.

The model is the major product of the western component of the Canada/United States (CANUSA) Spruce Budworm Program, which operated out of the Pacific Northwest Research Station in Portland, Oregon, from 1978 to 1984.

Managers have already played a vital role in helping build the model by contributing ideas. Last April, several of them tested a preliminary version at a workshop in Moscow, Idaho. They were organized into six teams and challenged to compete in selecting from the model the best strategies for managing five stands with specified constraints and budworm densities. During this process managers discovered changes needed to improve the model. These changes have now been made, and it is this improved model that needs further testing out in the "real world" of forest management.

The model can be accessed at the Fort Collins Computer Center. Contact Bov Eav at the Methods Application Group of Forest Pest Management (303/224-1784; FTS 323-1784) for further details.

Request user documents and report success, criticism, and suggestions to Jim Colbert (PNW Station, La Grande, Oregon; 503/963-7122) or Nick Crookston (INT Station, Moscow, Idaho; 208/882-3557).

Influences on anadromous fish habitat

Two new publications in the Pacific Northwest Station's series, *Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America* are now available. One explains how methods for evaluating costs and benefits can be used to measure the effects of forest and range management practices on anadromous fisheries. The other describes the relation among recreation activities, the demand for fishing opportunities, and the supply of anadromous fish habitat.

There are now 14 published reports in the series. Earlier reports were reviewed in *Forestry Research West* for February 1982 and January and June 1983.

Write to the Pacific Northwest Station for copies of *Economic Considerations*, General Technical Report PNW-181, and *Influences of Recreation*, General Technical Report PNW-178.

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